Integrated Circuit Card

10

16

Card Java Virtual Machine
(Card JVM)

12a

Communicator

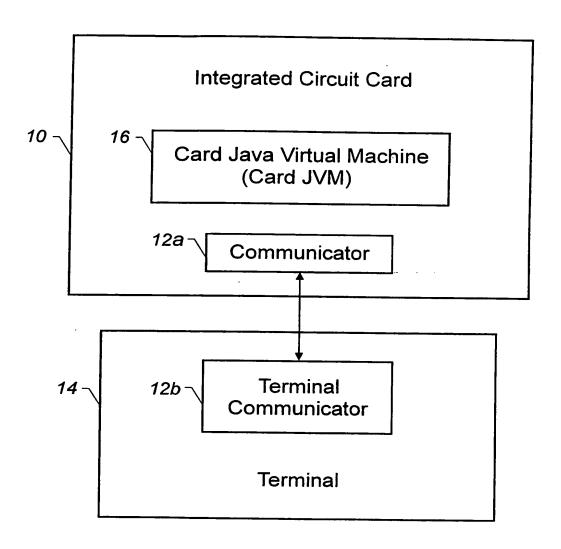14

12b

Terminal
Communicator

Terminal

FIGURE 1

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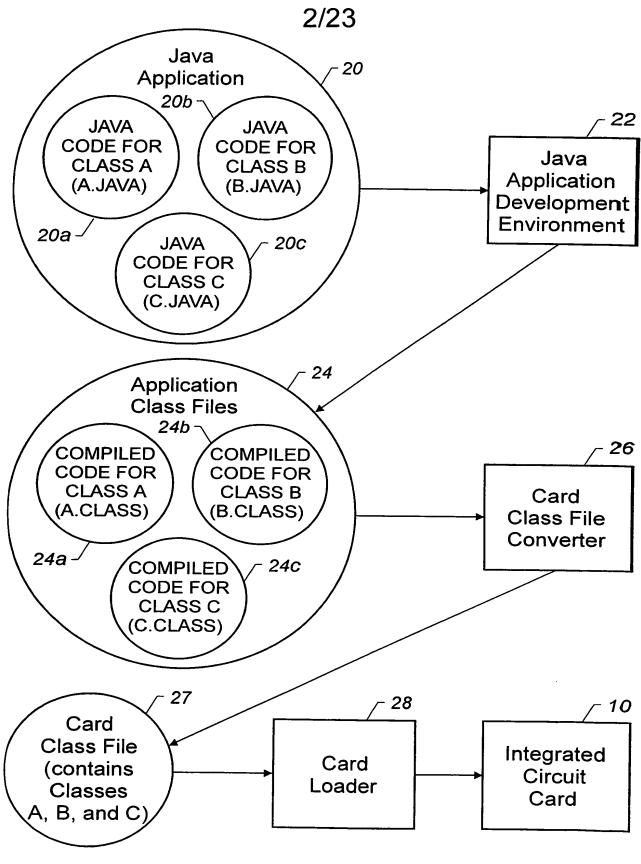Serial No. 10/037,390
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Java Application 20

20b

JAVA CODE FOR CLASS A (A.JAVA) 20a

JAVA CODE FOR CLASS B (B.JAVA)

JAVA CODE FOR CLASS C (C.JAVA) 20c

Java Application Development Environment 22

Application Class Files 24

24b

COMPILED CODE FOR CLASS A (A.CLASS) 24a

COMPILED CODE FOR CLASS B (B.CLASS)

COMPILED CODE FOR CLASS C (C.CLASS) 24c

Card Class File Converter 26

Card Class File (contains Classes A, B, and C) 27

Card Loader 28

Integrated Circuit Card 10

FIGURE 2

FIGURE 3

Application Class Files _____ 24

Class File Information

41 — Class File Information → Card Class File Information — 46

42 — Class Constant Pool - Contains all the strings corresponding to Fields methods and Class names referred to in the Java program → Optimized Card Class Constant Pool where each string is replaced by an ID — 47

43 — Class, field, Interface and Method Information → Card Class, Card Field, Card Interface and Card Method Information — 48

44 — Attribute Information

Card Attribute Information — 49

←Source File Attribute

Code Attribute (optionally translated)

←Constant Value Attribute

Code Attribute ——

←Exceptions Attribute

←Line Number Table Attribute

24b,c

←Local Variable Table Attribute

←Optional Vendor Attributes

45

Eliminated

24a

Card Class File — 27

Card Class File Information

FIGURE 4

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FIGURE 5

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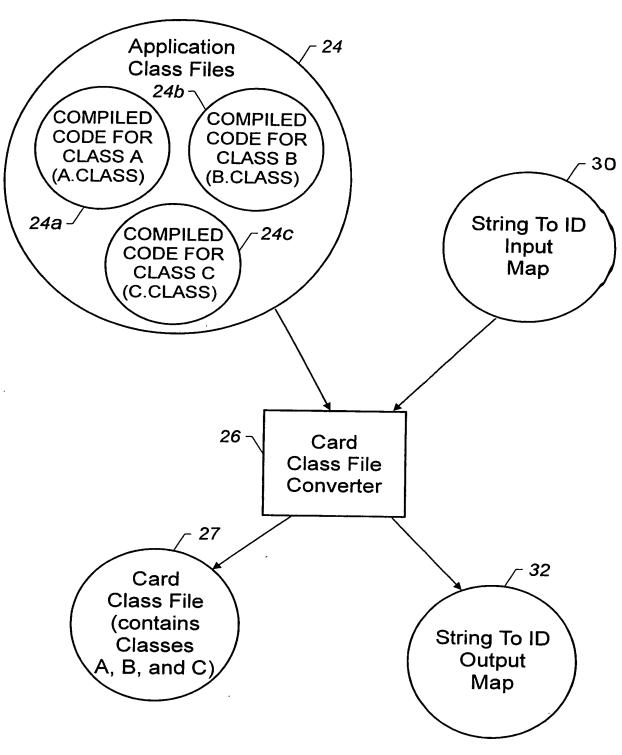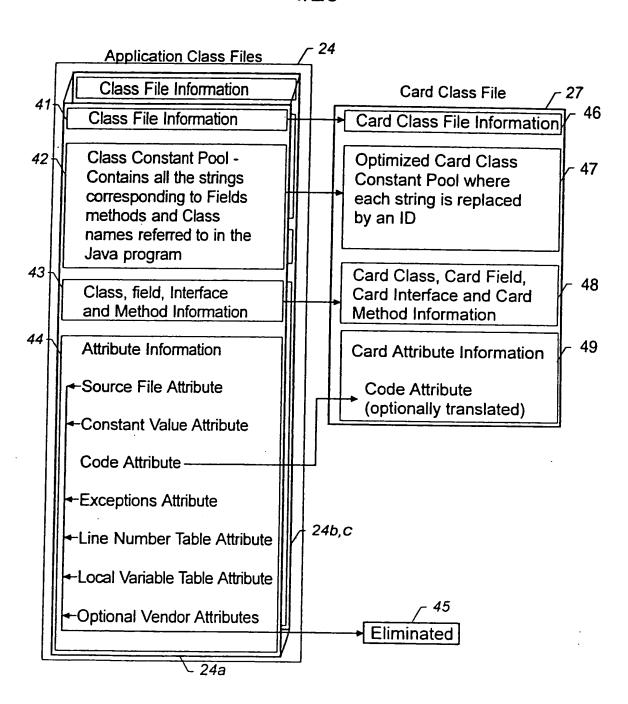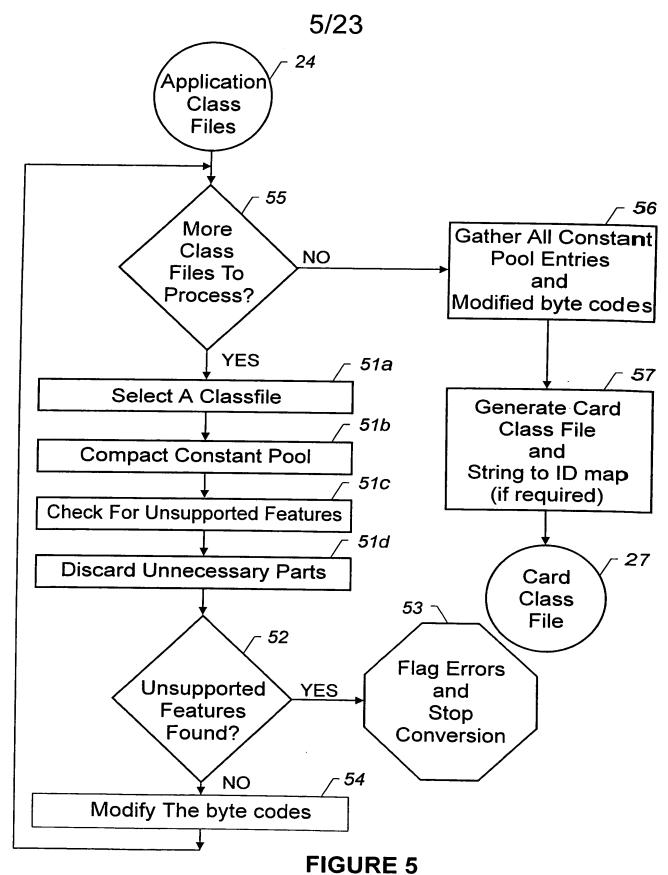Title: Using a High Level Programming Language with a Microcontroller
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```
        ( Original byte codes )
                  |  ——60                              ——61
                  v
┌─────────────────────────────────────────────────────┐
│       PASS 1: List all jumps and their destinations   │
└─────────────────────────────────────────────────────┘
                  |
                  v
                            ——62
            ◇ Translate
   NO ◄─────  specific
            byte codes? ◇
                  |
                  | YES                               ——63
                  v
┌─────────────────────────────────────────────────────┐
│  PASS 2: Convert specific byte codes into generic byte codes │
└─────────────────────────────────────────────────────┘
                  |                                   ——64
                  v
┌─────────────────────────────────────────────────────┐
│              PASS 3: Relink References                 │
└─────────────────────────────────────────────────────┘
                  |
                  v
                            ——65
            ◇ Modify byte
   NO ◄─────   codes? ◇
                  |
                  | YES                               ——66
                  v
┌─────────────────────────────────────────────────────┐
│  PASS 4: Modify Java byte codes to Card JVM byte codes │
└─────────────────────────────────────────────────────┘
                  |                                   ——67
                  v
┌─────────────────────────────────────────────────────┐
│              PASS 5: Readjust Jumps                    │
└─────────────────────────────────────────────────────┘
                  |                                   ——68
                  v
        ( Modified byte codes )
```

FIGURE 6

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tle: Using a High Level Programming Language with a   ntroller
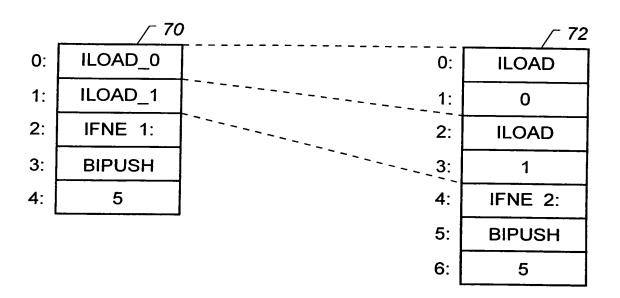erial No. 10/037,390
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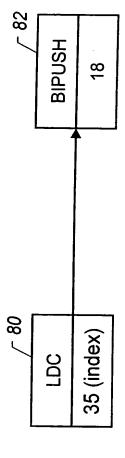| 0:	ILOAD_0
1:	ILOAD_1
2:	IFNE 1:
3:	BIPUSH
4:	5

70

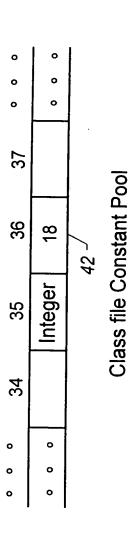| 0:	ILOAD
1:	0
2:	ILOAD
3:	1
4:	IFNE 2:
5:	BIPUSH
6:	5

72

FIGURE 7

Applicant: Wilkinson et al.
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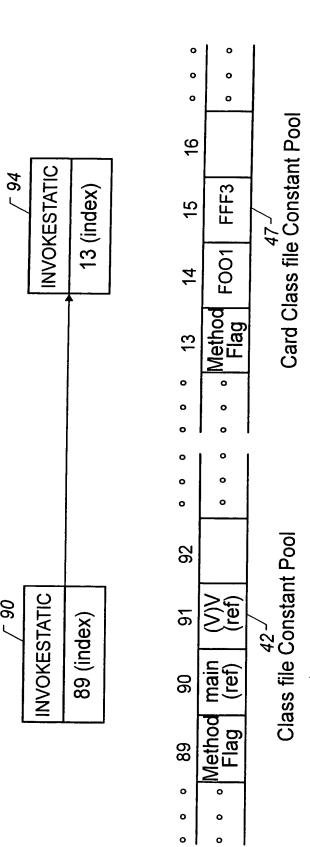Serial No. 10/037,390
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FIGURE 8

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FIGURE 9

	100
0:	ALOAD 43
1:	0
2:	ILOAD 21
3:	1
4:	IFNE 154 2:
5:	BIPUSH 16
6:	5

	102
0:	ALOAD 51
1:	0
2:	ILOAD 50
3:	1
4:	IFNE 27 2:
5:	BIPUSH 49
6:	5

FIGURE 10

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ILOAD	␣112
8

ILOAD_B	␣116
8

Word-Based Operand
Stack

Byte-Based Operand
Stack

FIGURE 11

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FIGURE 12

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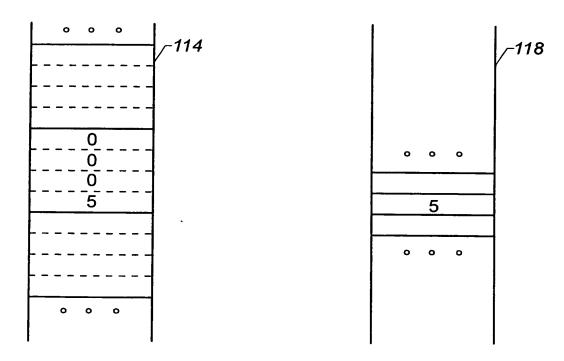Contact: Pehr B. Jansson, 512-331-3748

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FIGURE 13

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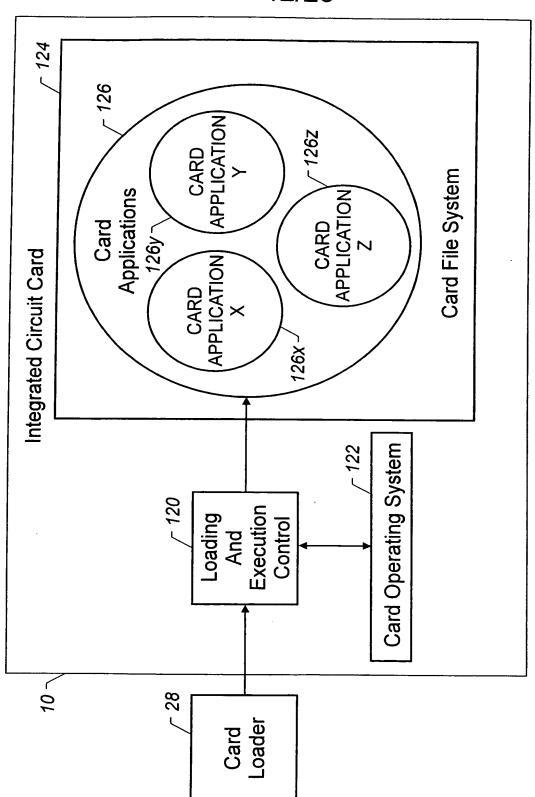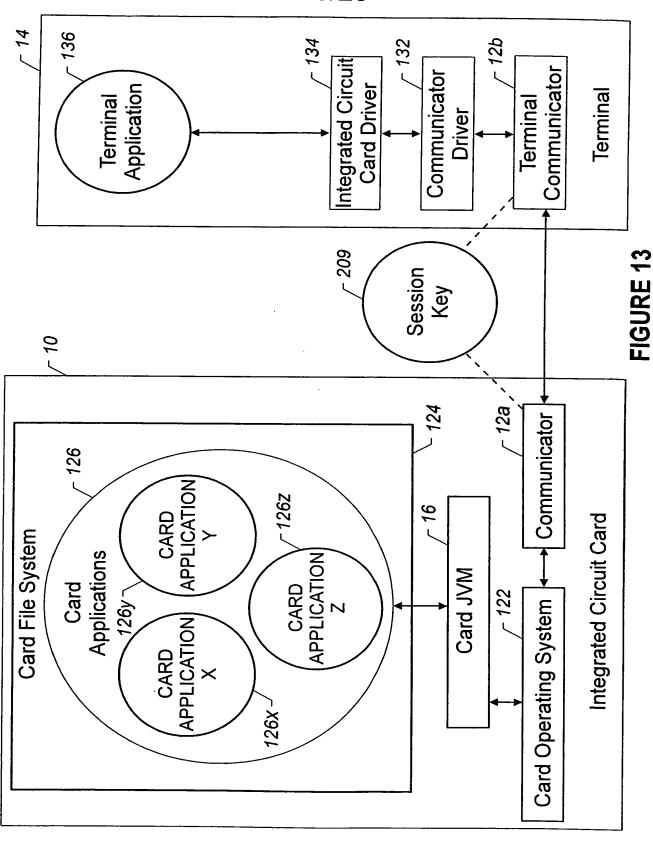**FIGURE 14**

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```
        ┌──────────────────────┐  ┌ 120          ┌ 126z
        │  Execution Control   │◄──────   ⬭ Card Application ⬭
        └──────────────────────┘
                   │
                   ▼
        ┌──────────────────────┐  ┌ 152
        │   Find Entry point   │
        │  class ID/method ID  │
        └──────────────────────┘
                   │
                   ▼
        ┌──────────────────────┐  ┌ 153
        │   Interpret method    │
        └──────────────────────┘
                   │
                   ▼
              ◇ 154
        Unhandlable
        Exception/Error ──── NO ────┐
        encountered                 │
              │                      ▼
             YES              ⬠ 156
              │              Stop
              ▼              Card JVM
        ┌──────────────────┐ and send Error
        │  Report Success  │ to terminal
        └──────────────────┘  ┌ 155
```

FIGURE 15

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```
Method                    ┌─ 160
```

┌─ 161

Set VM stack Parameters Set Card JVM program Counter

┌─ 162

Check method flag, if native? ──── YES

┌─ 163

Handle native method Place return value on VM Stack

NO

┌─ 164

YES ──── **Finished interpreting method?**

NO

┌─ 165

166 ─ | **Empty VM Stack** | **A branch to be taken?** ──── YES

165a ─ **Prepare for branch**

NO

┌─ 167

Stop Execution

| **Retrieve next byte code/type information** | ┌─ 165b

| **Check VM stack state (Pass 3 security checks)** | ┌─ 165c

| **Execute byte code** | ┌─ 165d

| **Set VM stack state** | ┌─ 165e

| **Retire the byte code** | ┌─ 165f

FIGURE 16

```
                        ┌─ 171
              ╭─────────────────────╮
              │    a byte code      │
              ╰─────────────────────╯
                        │
                        ▼
                              ┌─ 172
         ┌──────────────────────────────┐
         │      execute bytecode        │
         └──────────────────────────────┘
                        │
                        ▼
                              ┌─ 173
              ◇───────────────────◇
             ╱     Resource        ╲          NO
            ◇     limitation        ◇─────────────┐
             ╲  encountered?       ╱              │
              ◇───────────────────◇               │
                        │                         │
                      YES                         │
                        │                         │
                        ▼      ┌─ 175             │
         ┌──────────────────────────────┐         │
         │      Report Success          │         │
         └──────────────────────────────┘         │
                                                  │
                                                  ▼
                                    156 ┐  ┌──────────────┐
                                        ╲ │     Stop     │
                                          │  Card JVM    │
                                          │    and       │
                                          │ Send error to│
                                          │  terminal    │
                                          └──────────────┘
```
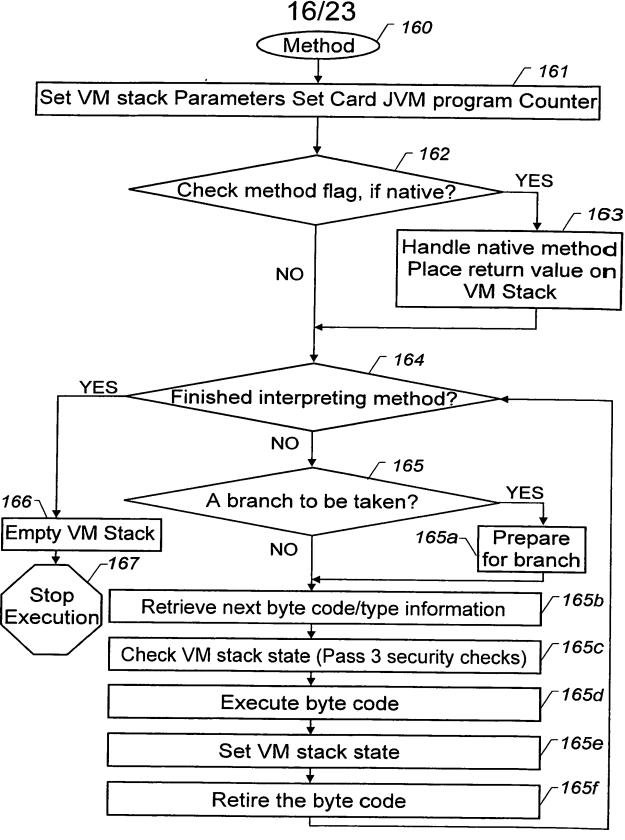
FIGURE 17

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Serial No. 10/037,390
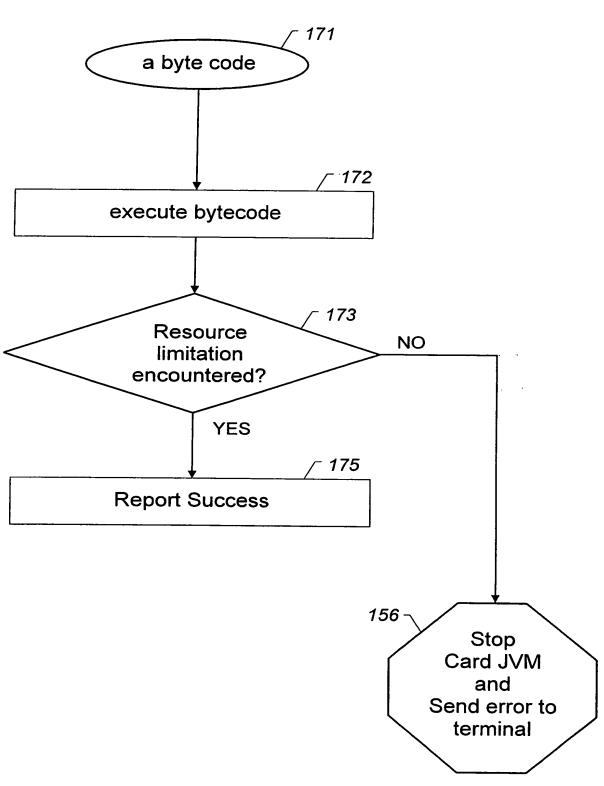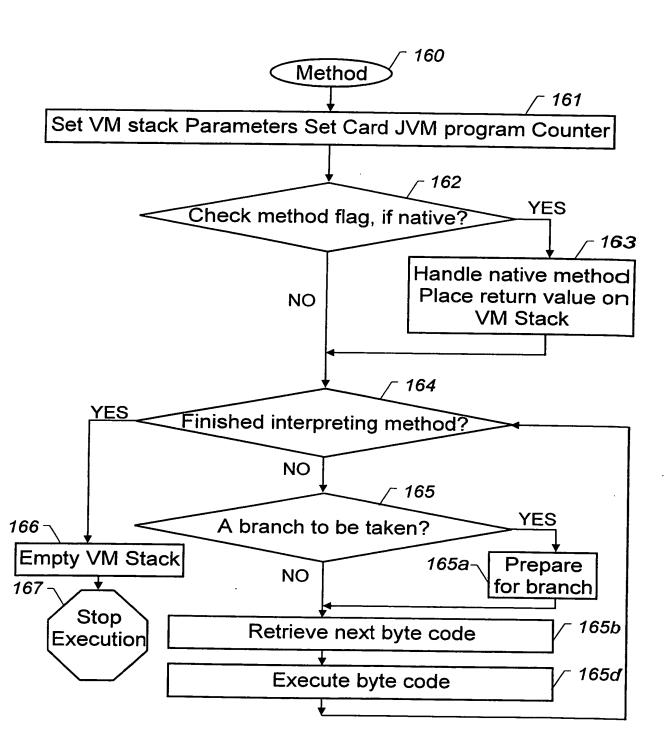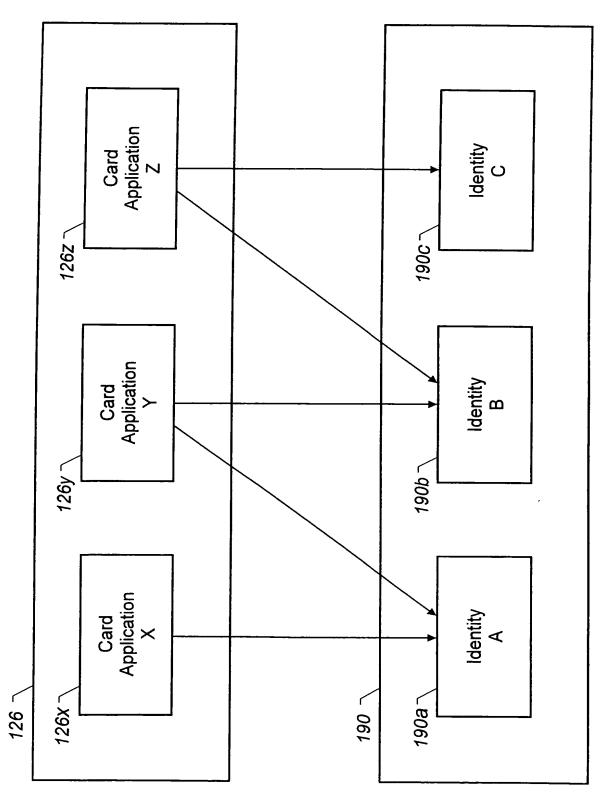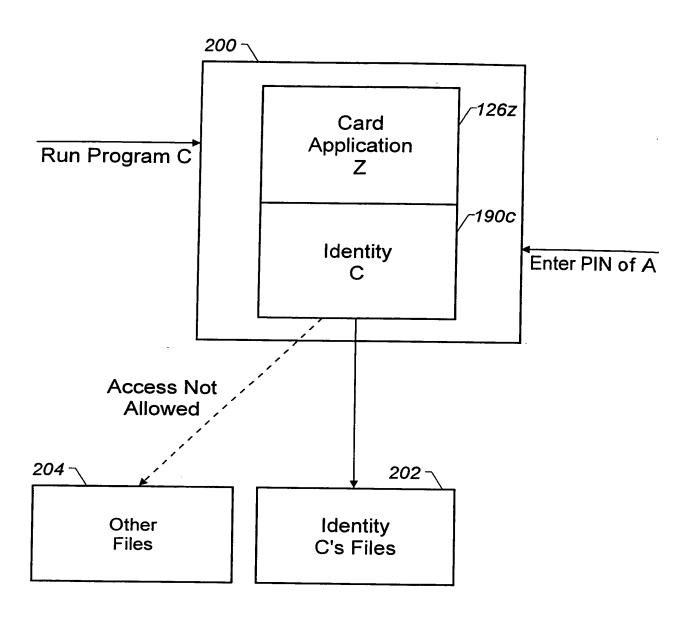Contact: Pehr B. Jansson, 512-331-3748

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```
                            ┌──────────┐  ⌐ 160
                            │  Method  │
                            └──────────┘
                                 │
┌─────────────────────────────────────────────────────────────┐ ⌐ 161
│ Set VM stack Parameters Set Card JVM program Counter         │
└─────────────────────────────────────────────────────────────┘
                                 │
                                 ▼                    ⌐ 162
                    ◇ Check method flag, if native? ◇──── YES
                                 │                           │
                                 │                           ▼        ⌐ 163
                                 │              ┌────────────────────────┐
                                 │              │ Handle native method   │
                                NO              │ Place return value on  │
                                 │              │ VM Stack               │
                                 │              └────────────────────────┘
                                 ▼
                                              ⌐ 164
   YES ───── ◇ Finished interpreting method? ◇
    │                            │
    │                           NO
    │                            │
    ▼                            ▼            ⌐ 165
┌──────────────┐   ◇ A branch to be taken? ◇──── YES
│Empty VM Stack│            │                       │
└──────────────┘           NO          165a ─┐      ▼
  166 ─┘                     │                 ┌──────────┐
                             │                 │ Prepare  │
  167 ─┐                     │                 │for branch│
  ┌──────────┐               │                 └──────────┘
  │  Stop    │               ▼
  │Execution │  ┌──────────────────────────────┐ ⌐ 165b
  └──────────┘  │   Retrieve next byte code    │
                └──────────────────────────────┘
                ┌──────────────────────────────┐ ⌐ 165d
                │      Execute byte code        │
                └──────────────────────────────┘
```
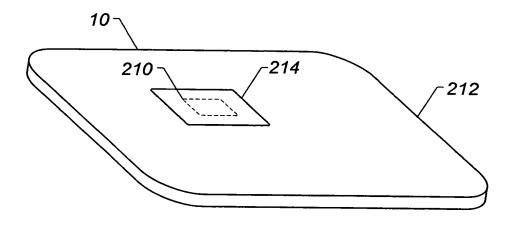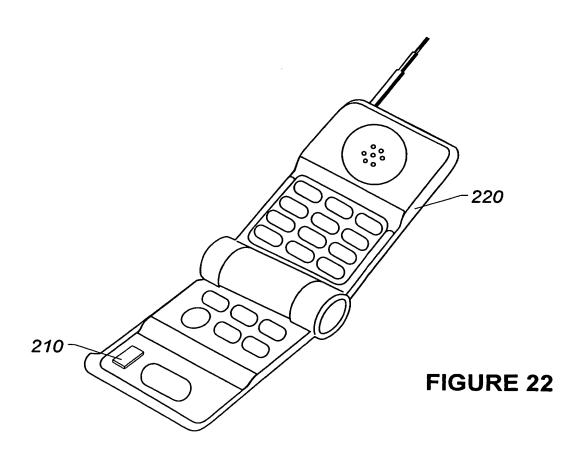
FIGURE 18

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FIGURE 19

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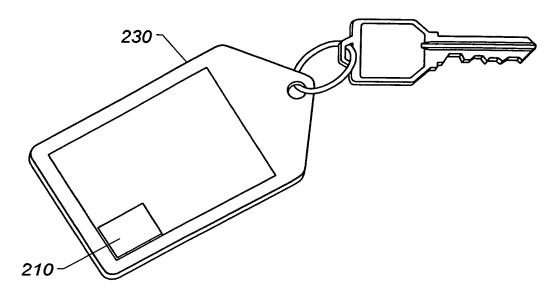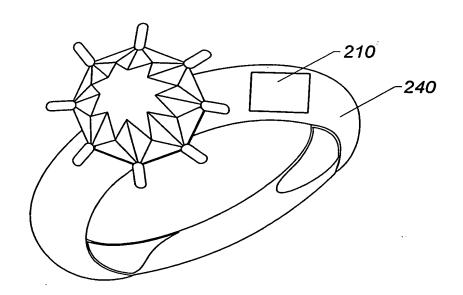Serial No. 10/037,390
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FIGURE 20

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FIGURE 21

FIGURE 22

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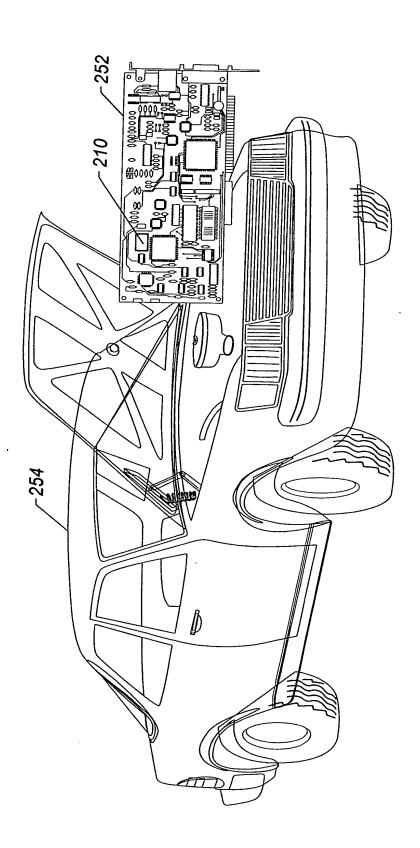Serial No. 10/037,390
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FIGURE 23

FIGURE 24

FIGURE 25